Impact of Aerosols on Convective Clouds and Precipitation

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ABSTRACT

Aerosols are a critical factor in the atmospheric hydrological cycle and radiation budget. As a major agent for clouds to form and a significant attenuator of solar radiation, aerosols affect climate in several ways. Current research suggests that aerosol effects on clouds could further extend to precipitation, both through the formation of cloud particles and by exerting persistent radiative forcing on the climate system that disturbs dynamics. However, the various mechanisms behind these effects, in particular the ones connected to precipitation, are not yet well understood. The atmospheric and climate communities have long been working to gain a better grasp of these critical effects and hence to reduce the significant uncertainties in climate prediction resulting from such a lack of adequate knowledge.

Here we review past efforts and summarize our current understanding of the effect of aerosols on convective precipitation processes from theoretical analysis of microphysics, observational evidence, and a range of numerical model simulations. In addition, the discrepancy between results simulated by models, as well as that between simulations and observations, are presented. Specifically, this paper addresses the following topics: (1) fundamental theories of aerosol effects on microphysics and precipitation processes, (2) observational evidence of the effect of aerosols on precipitation processes, (3) signatures of the aerosol impact on precipitation from large-scale analyses, (4) results from cloud-resolving model simulations, and (5) results from large-scale numerical model simulations. Finally, several future research directions for gaining a better understanding of aerosol–cloud-precipitation interactions are suggested.